RECTANGULAR DIELECTRIC RESONATOR ANTENNA CONFIGURATIONS FOR MOBILE COMMUNICATION APPLICATIONS

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ABSTRACT: *Experimental investigations on Microstrip line excited Dielectric Resonator Antenna configurations suitable for Mobile Communication applications are reported. High permittivity ($\varepsilon r_d = 48$) resonator samples with different aspect ratios are employed for the study. Theoretical analysis performed using FDTD method is also presented.*

Key words: *Rectangular Dielectric Resonator Antenna; Mobile Communication*

INTRODUCTION

Ceramic antenna solutions for Mobile Communication devices offer themselves as a better alternative to their conventional counterparts [1]. The Dielectric Resonator Antenna (DRA) is an open resonating structure, known for its radiation efficiency. Though Dielectric Resonators (DR's) of different shapes have been investigated [2-3], rectangular Dielectric Resonators are preferred because they are easy to fabricate and offer more degrees of freedom to control the resonant frequency and quality factor [4]. The effect of the dimensions of the feed line and ground plane on the radiation characteristics of a Microstrip line excited rectangular DRA has been demonstrated experimentally [5]. The paper presents the outcome of the experimental investigations performed on Microstrip Line fed Rectangular DRA configurations suitable for Mobile communication applications. High permittivity ($\varepsilon r_d = 48$) resonator samples of varying dimensions are used for the study. Numerical analysis employing FDTD method is reported along with the experimental results.

ANTENNA CONFIGURATION

A schematic lay out of the antenna configuration is shown in Fig.1. The high permittivity ($\varepsilon r_d = 48$) rectangular Dielectric Resonator is excited directly by a 50Ω Microstrip Line. The feed line is fabricated on a substrate of dielectric constant $\varepsilon_{rs} = 4.28$ and thickness $h_s = 1.6$ mm. The length of the feed line is chosen to be twice the resonator length ($l_f = 2l_d$). Resonator samples of varying dimensions are employed for the investigations, as detailed in Table.1.

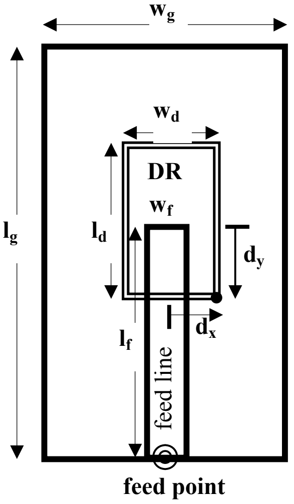

Fig.1 Lay out of the Microstrip line excited rectangular DRA
Feed dimensions: $l_f = 6.8$ cm, $w_f = 0.3$ cm
Ground plane dimensions: $l_g = 9$ cm, $w_g = 4$cm

Table.1 The proposed antenna configuration

Antenna	DR dimensions			Aspect ratio	DR Position	Frequency band
	l_d cm	w_d cm	h_d cm	(h_d/w_d)	(dx,dy) cm	
DR_$_1$	3.4	1.7	1.1	0.65	1,4.2	GSM 1800
DR_$_2$	3.4	1.7	0.555	0.33	0.75,5.5	2.4 GHz WLAN
DR_$_3$	3.4	1.1	1.7	1.56	0.5,5	GPS
DR_$_4$	3.4	0.555	1.7	3.06	0.25,2.5	PCS 1900

RESULTS AND DISCUSSION

HP 8510C Network Analyser is used for antenna measurements. The offset distance of the DR from the feed (d_x,d_y) is a frequency tuning parameter, determining the resonant behaviour of the antenna. The positions of the resonator samples are optimized in order to excite the frequencies in the required bands. The return loss and input impedance characteristics of the antenna employing two samples of the same cross-sectional dimensions, but different heights is plotted in Fig.2. The characteristics of the antenna employing two resonator samples of the same height, but different widths is illustrated in Fig.3. The operating bands of the configurations cover the GSM 1800 (1710-1880 MHz), 2.4 GHz WLAN (2.4-2.484 GHz), GPS (1.565-1.585 GHz) and PCS 1900 (1.85-1.99 GHz) frequency bands, exhibiting 3.12%, 5.3%, 6.13% and 5.2% 2:1 VSWR bandwidth respectively. Fig.4. shows the gain exhibited by the antenna configuration at 2.4 GHz. Good gain (> 6 dBi) is offered by all the configurations.

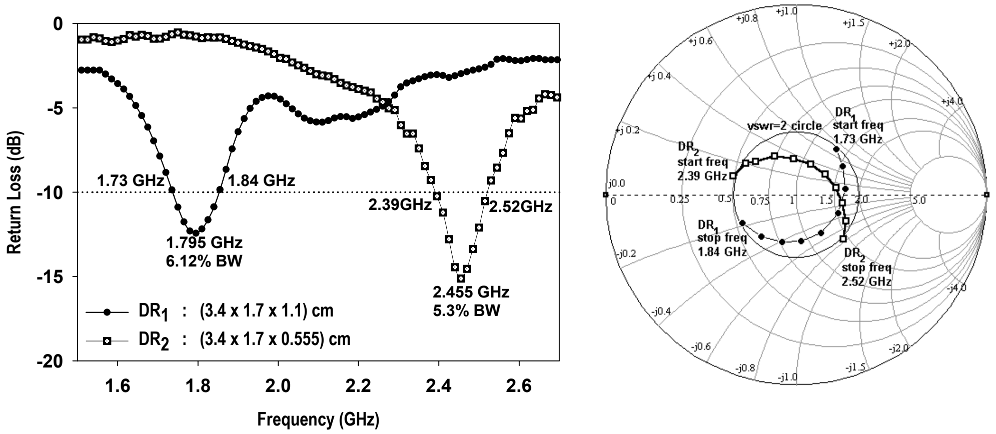

Fig.2. Characteristics of the Antenna configurations employing two samples of different heights
(a) Return Loss (b) Input impedance (frequency increasing in the clockwise direction)

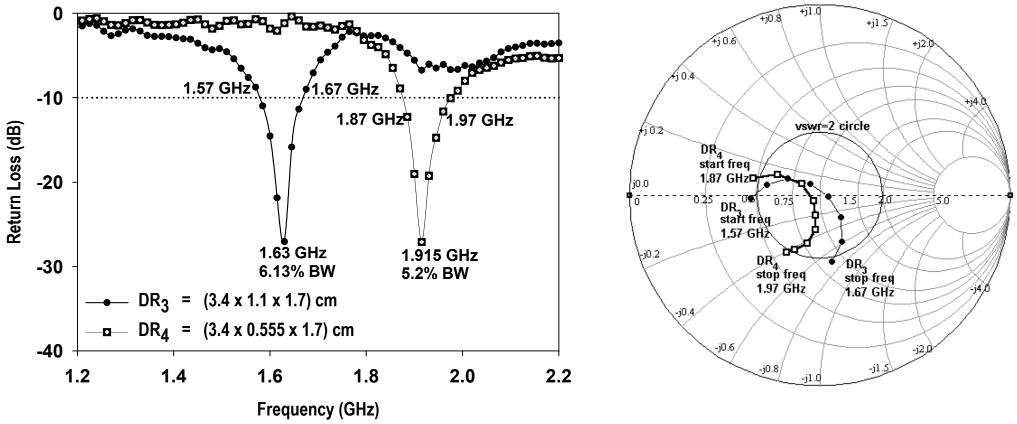

Fig.3. Characteristics of the Antenna configurations employing two samples of different widths
(a) Return Loss (b) Input impedance (frequency increasing in the clockwise direction)

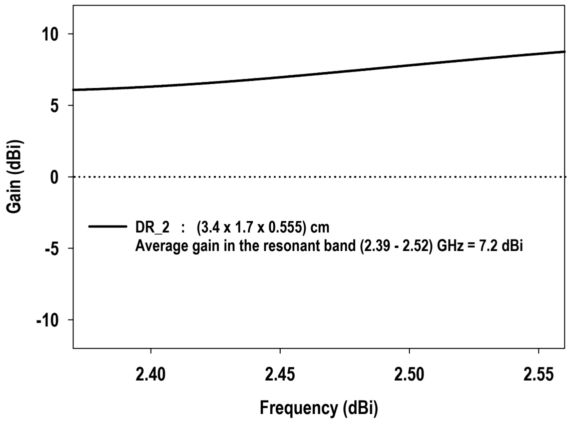

Fig.4. Gain of the Antenna configuration in the 2.4 GHz WLAN band

The finite difference time domain (FDTD) method is used to analyse the antenna. A Gaussian pulse of half-width T=15 ps and time delay t_0=3T is applied at the source plane. The time step used is Δt=1.155 ps. The cell size is chosen so that an integral number of cells fit within the DR and the substrate. (Δx = 0.5mm, Δy = 0.5mm and Δz = 0.4mm). The numerical results agree well with the experimental data. Fig.5. compares the return loss of the antenna obtained experimentally and theoretically in the 2.4 GHz WLAN band. The fractional difference between the numerical and experimental resonant frequency is -1.4%. The resonant modes have been identified theoretically and are listed in Table.2. The principal plane radiation patterns are broad in all the configurations, indicating the usefulness of the antenna for Mobile Communication applications. The radiation patterns in the 2.4 GHz WLAN band obtained theoretically and experimentally are compared in Fig.6. The antenna is found to exhibit linear polarization, along the dimension of the DR parallel to the feed axis. The features of the radiation patterns are summarized in Table.3.

CONCLUSIONS

Results of the experiments performed on rectangular DRA configurations employing different resonator samples (εr_d = 48) excited by a 50 Ω Microstrip Line are presented. FDTD analysis of the antenna gives results closely matching with the experiment. Good bandwidth, broad radiation patterns and moderate gain highlight the significance of the proposed antenna configurations in Mobile Communication bands – GPS, PCS 1900, GSM 1800 and 2.4 GHz ISM.

ACKNOWLEDGEMENTS

S.Mridula acknowledges SERC, Department of Science and Technology, Govt of India for financial assistance under the fast track scheme. P.Mohanan acknowledges UGC for financial support.

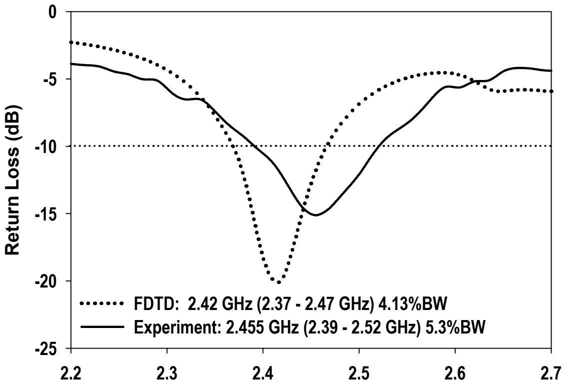

Fig.5. Experimental and theoretical return loss characteristics of the antenna configuration in the 2.4 GHz ISM band

Table.2 Radiation characteristics of the proposed antenna configuration

Antenna	Experiment		Theory		% error in freq	Res: mode	Gain dBi
	Freq GHz	%BW	Freq GHz	%BW			
DR_$_1$	1.795	6.12	1.8	4.1	-0.3	$TE_{01\delta}$	6.6
DR_$_2$	2.455	5.3	2.42	4.13	+1.42	$TE_{02\delta}$	7.2
DR_$_3$	1.63	6.13	1.6	4.7	+1.84	$TE_{01\delta}$	6.2
DR_$_4$	1.915	5.2	1.9	6.3	+0.78	$TE_{01\delta}$	5.8

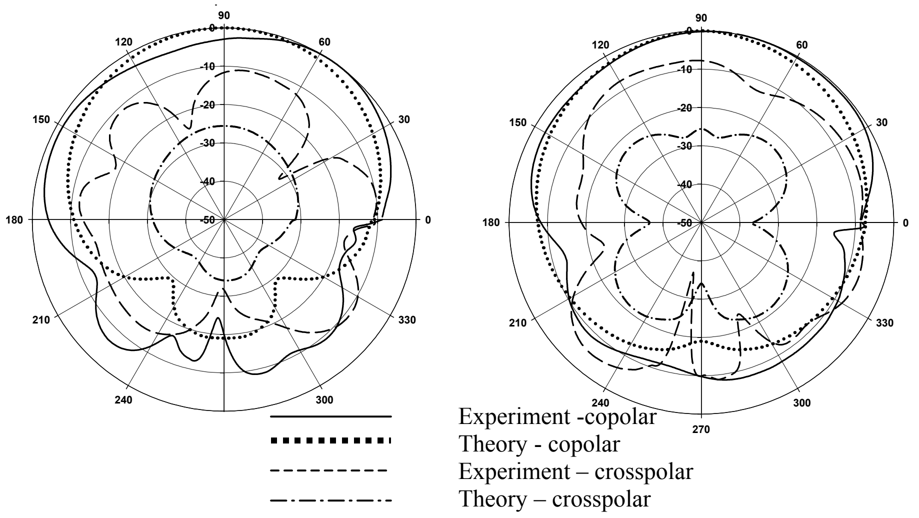

Fig.6. Radiation Pattern of the Antenna configuration at 2.4 GHz

Table.3 Radiation pattern characteristics in the 2.4 GHz ISM band

	Half power beam width (degree)		Direction of the beam maxima (degree)		Front-to-Back Ratio along the maxima (dB)		Cross-Polarisation along the maxima (dB)	
	E plane	H plane	E plane	H plane	E plane	H plane	E plane	H plane
Exp	67	118	56	81	9	12	-14	-9
Theory	90	90	90	90	20	20	-26	-26

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